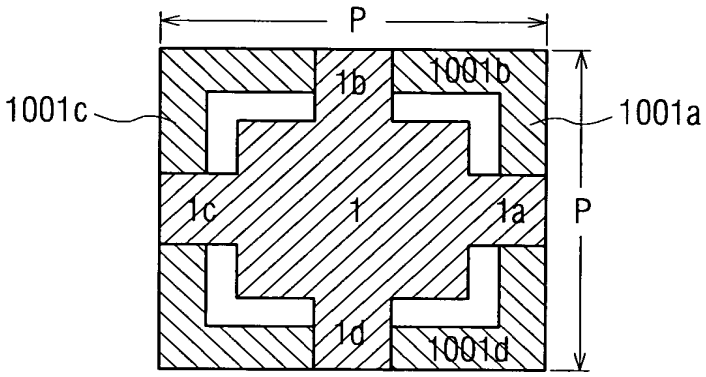

P
1001c
1b
1001b
1001a
1c
1
1a
P
1d
1001d

FIG. 1A

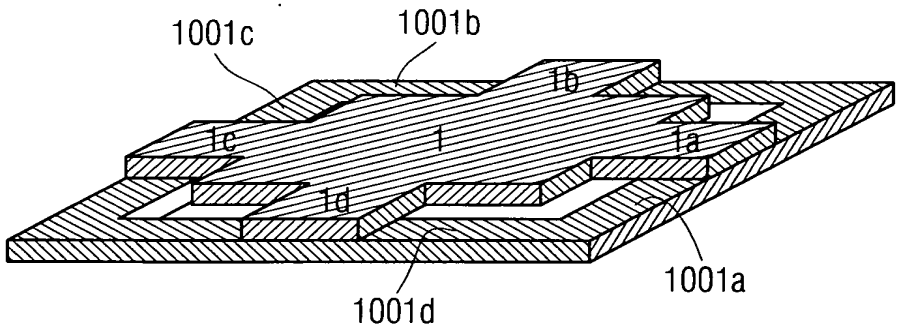

1001c
1001b
1b
1c
1
1a
1d
1001a
1001d

FIG. 1B

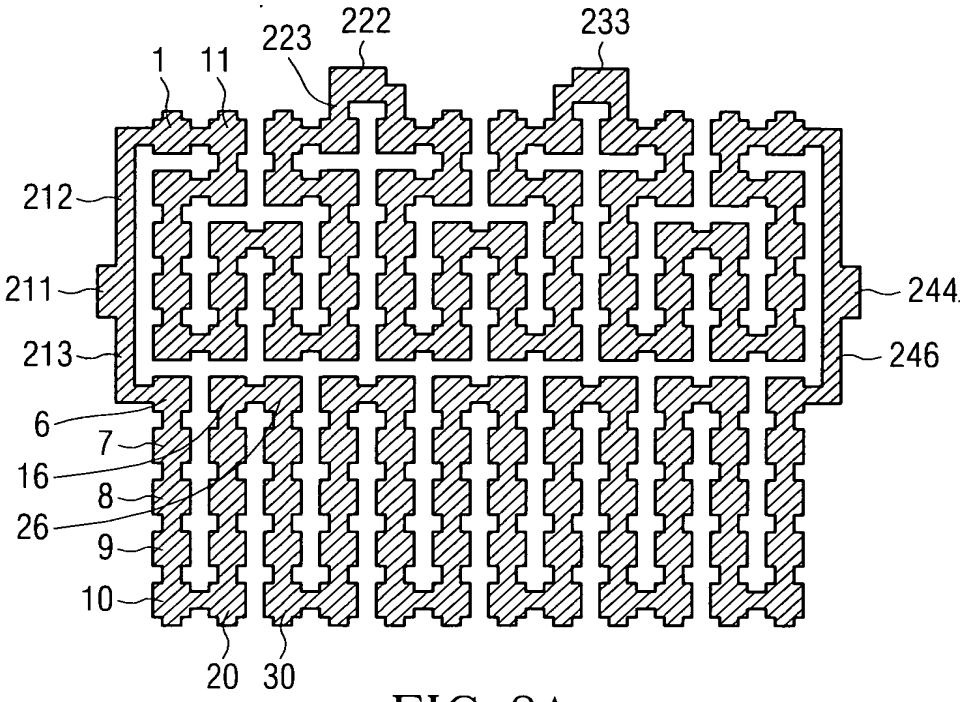


FIG. 2A

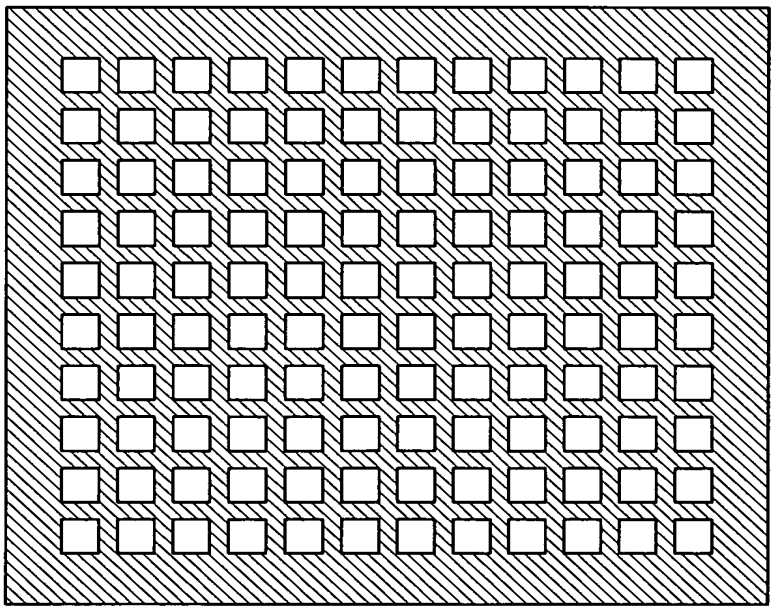


FIG. 2B

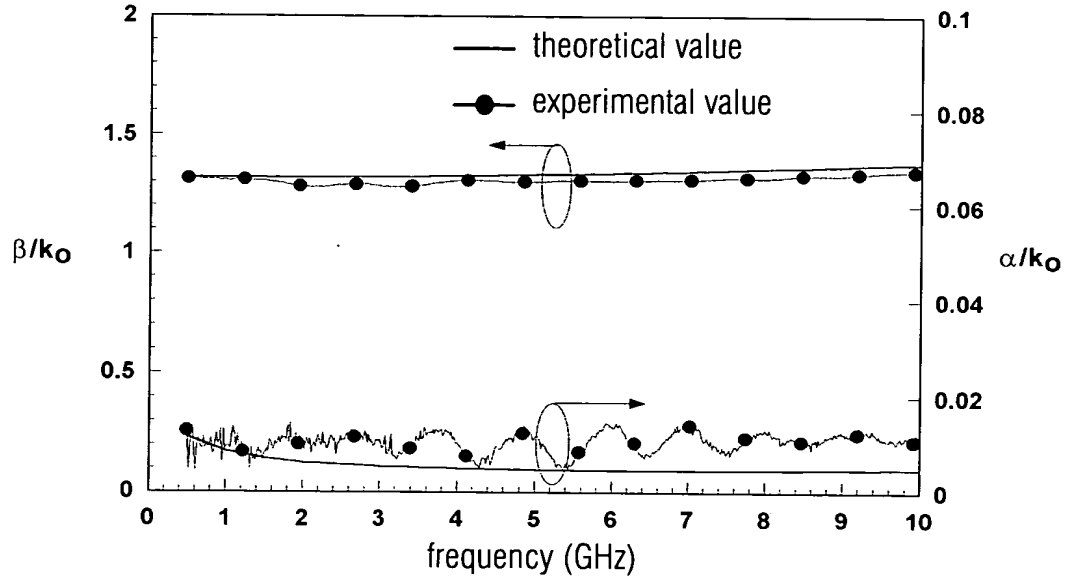

theoretical value
experimental value
β/k0
α/k0
frequency (GHz)
2
1.5
1
0.5
0
0.1
0.08
0.06
0.04
0.02
0
0 1 2 3 4 5 6 7 8 9 10

FIG. 3

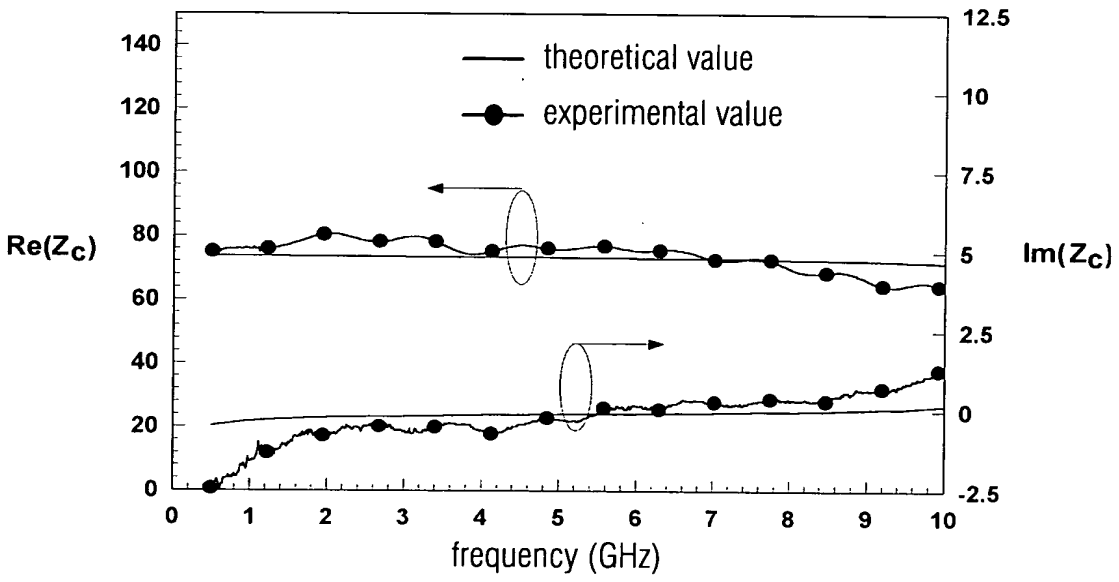

theoretical value
experimental value
Re(Zc)
Im(Zc)
frequency (GHz)
140
120
100
80
60
40
20
0
12.5
10
7.5
5
2.5
0
-2.5
0 1 2 3 4 5 6 7 8 9 10

FIG. 4

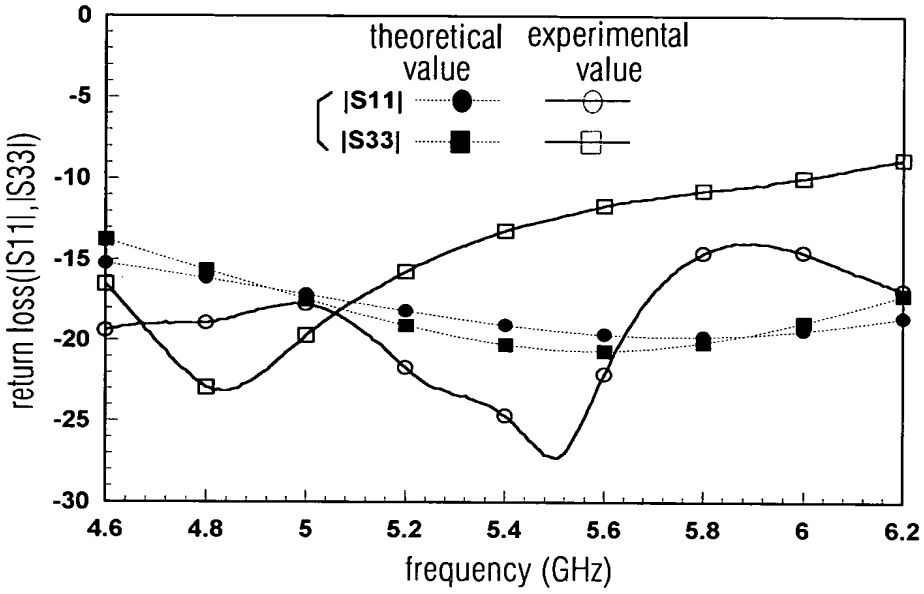

theoretical value
experimental value
|S11|
|S33|
return loss(|S11|,|S33|)
0
-5
-10
-15
-20
-25
-30
4.6
4.8
5
5.2
5.4
5.6
5.8
6
6.2
frequency (GHz)

FIG. 5A

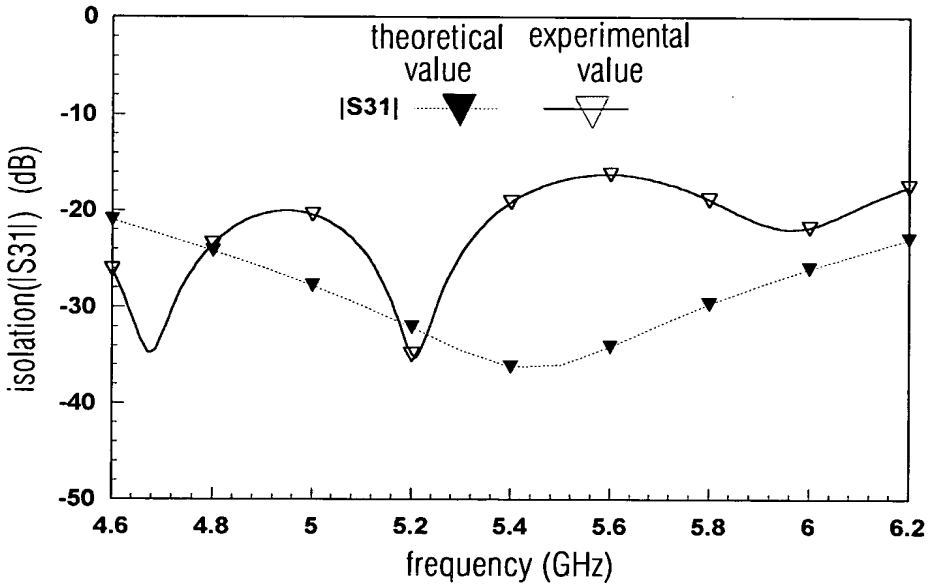

theoretical value
experimental value
|S31|
isolation(|S31|) (dB)
0
-10
-20
-30
-40
-50
4.6
4.8
5
5.2
5.4
5.6
5.8
6
6.2
frequency (GHz)

FIG. 5B

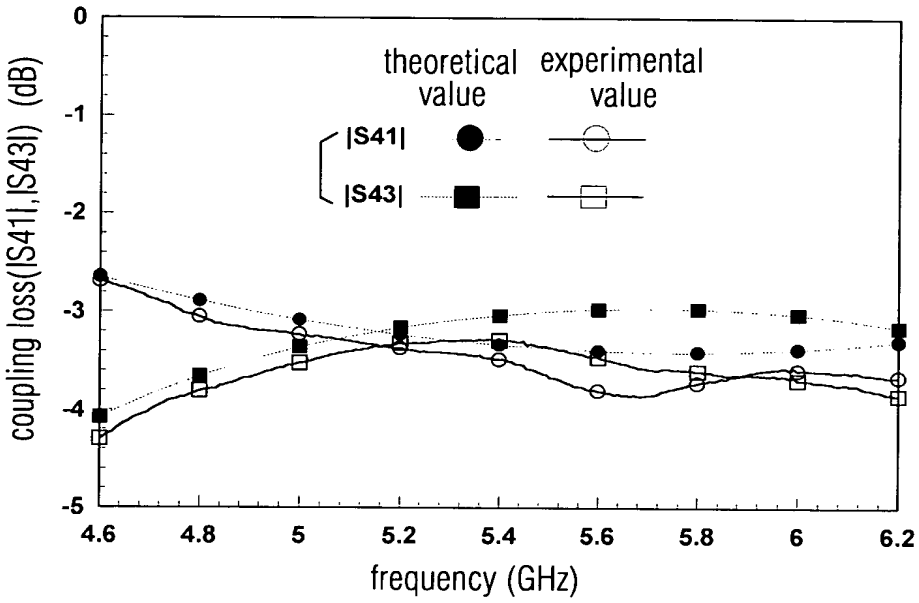

0
-1
-2
-3
-4
-5
coupling loss(|S41|,|S43|) (dB)
theoretical value
experimental value
|S41|
|S43|
4.6
4.8
5
5.2
5.4
5.6
5.8
6
6.2
frequency (GHz)

FIG. 5C

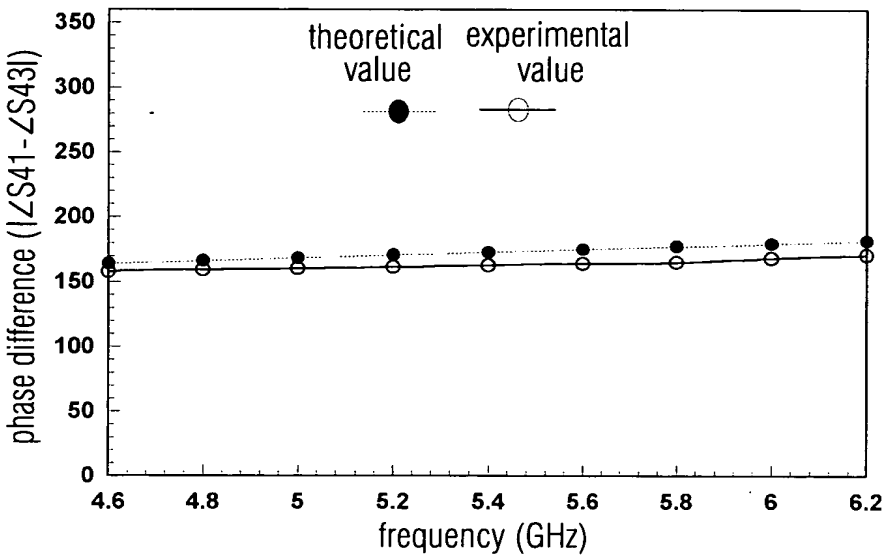

theoretical value
experimental value
phase difference (∠S41-∠S43)
350
300
250
200
150
100
50
0
4.6
4.8
5
5.2
5.4
5.6
5.8
6
6.2
frequency (GHz)

FIG. 6

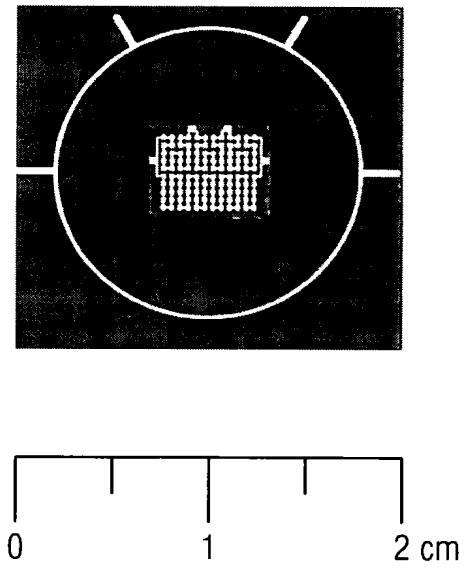


FIG. 7

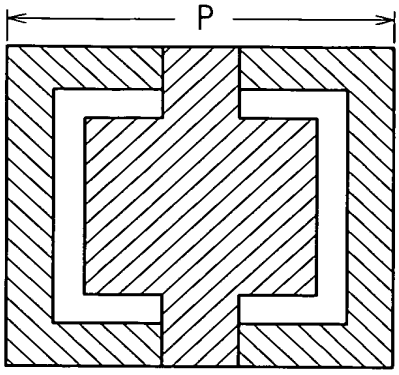


FIG. 8A

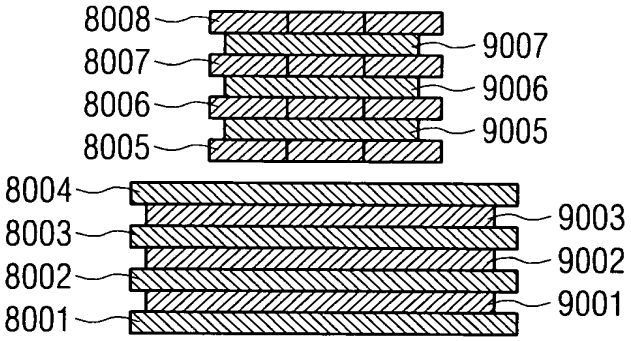


FIG. 8B

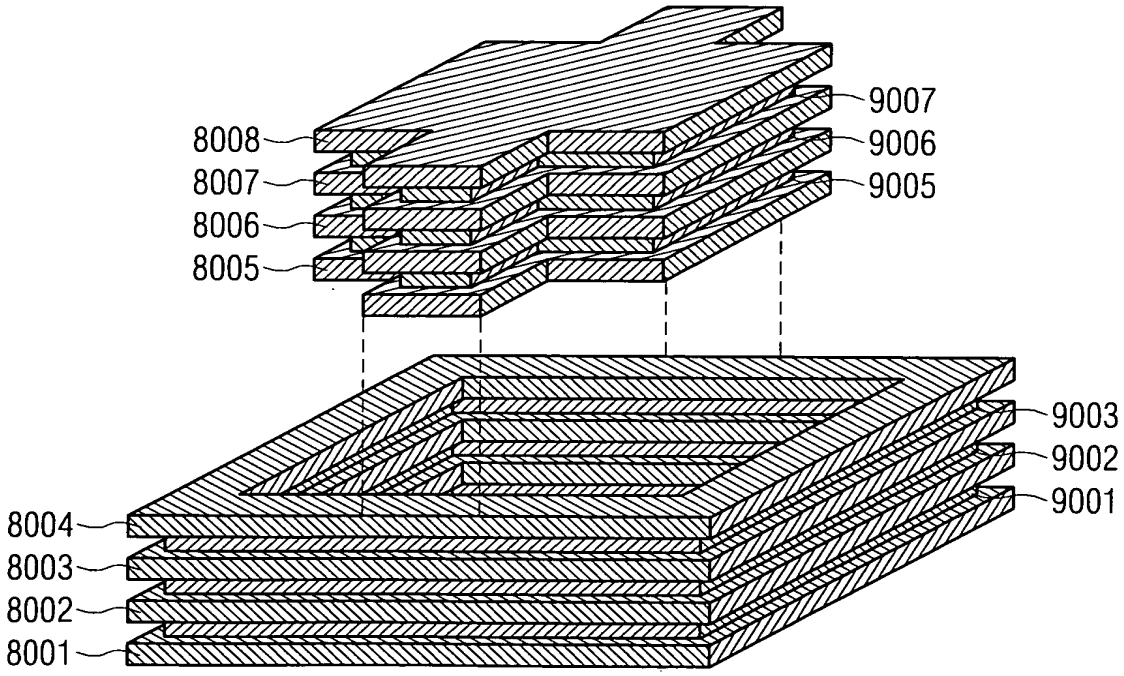


FIG. 8C

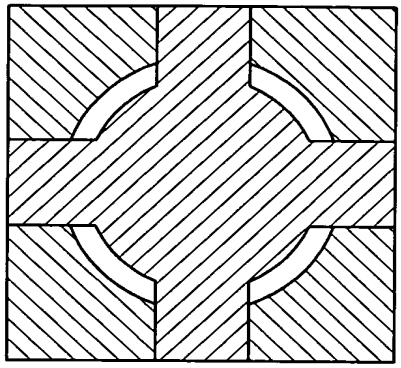


FIG. 9

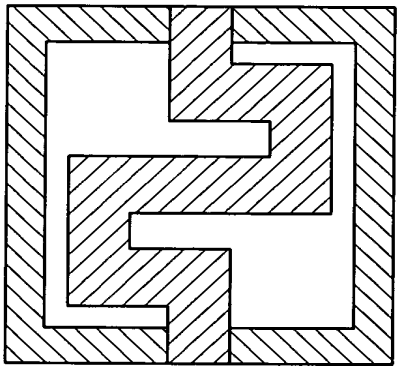


FIG. 10A

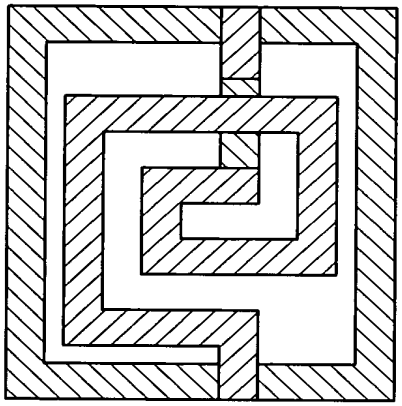


FIG. 10B

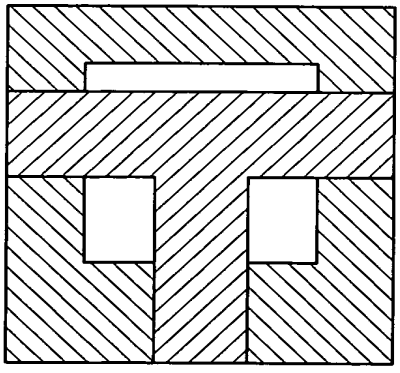


FIG. 10C

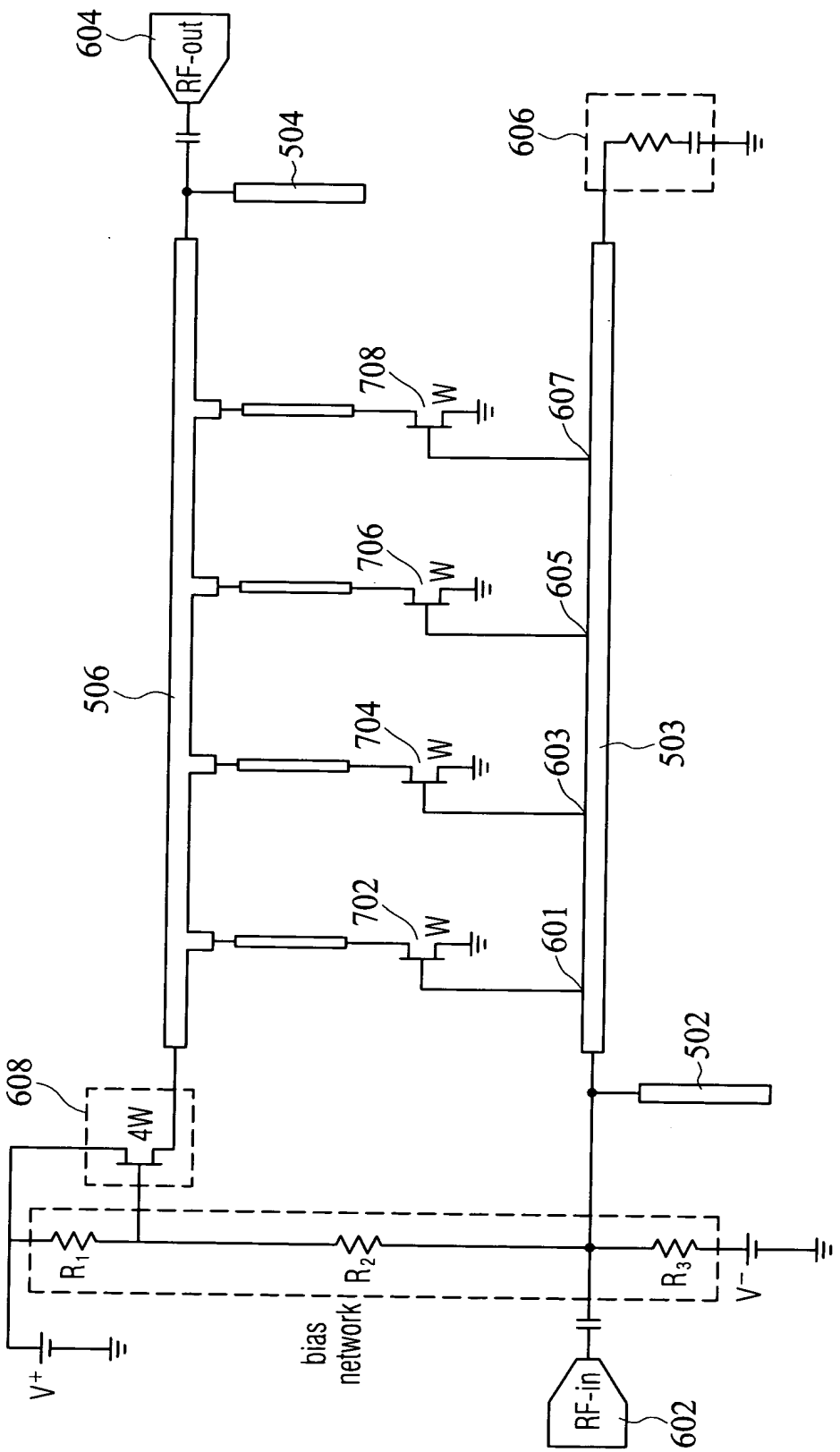

604
RF-out
504
606
708
W
607
706
W
605
506
704
W
603
503
702
W
601
608
4W
502
R1
R2
R3
V+
V−
bias
network
RF-in
602

FIG. 11

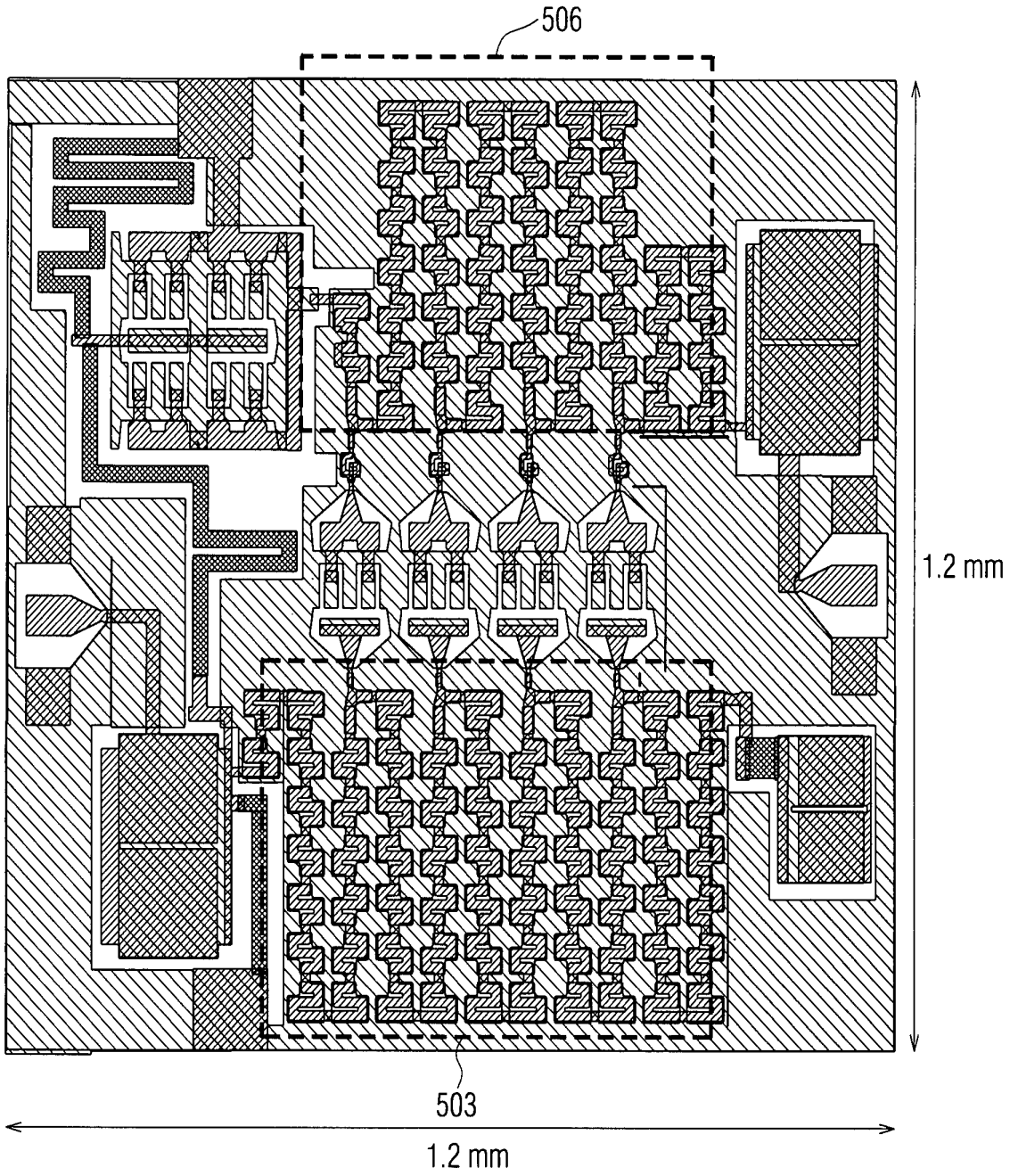
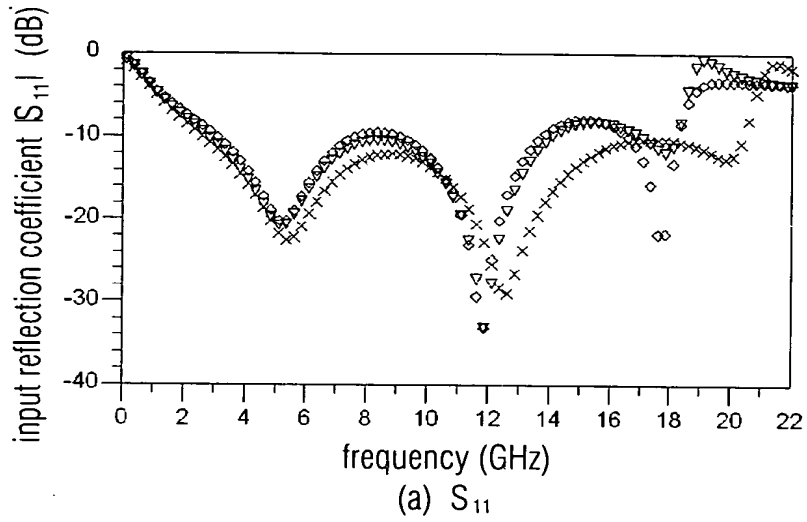
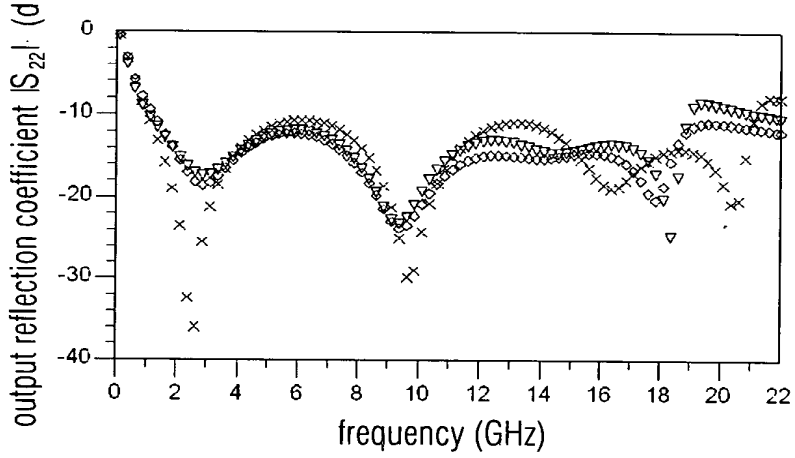


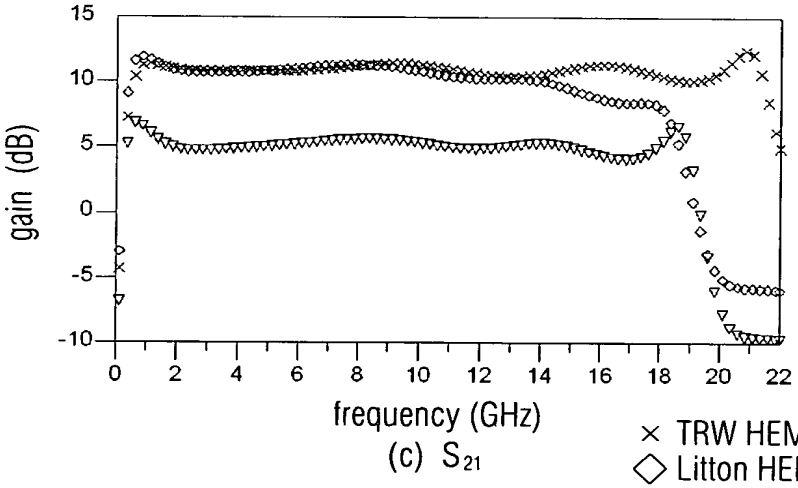
FIG. 12



(a) S_{11}



(b) S_{22}



(c) S_{21}

FIG. 13

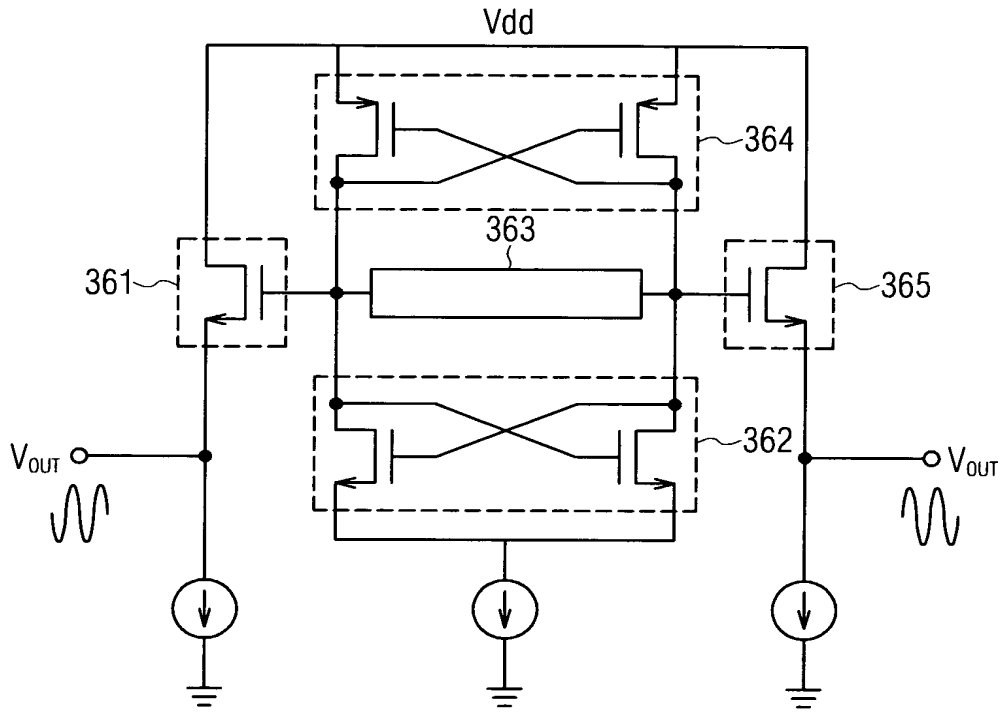


FIG. 14

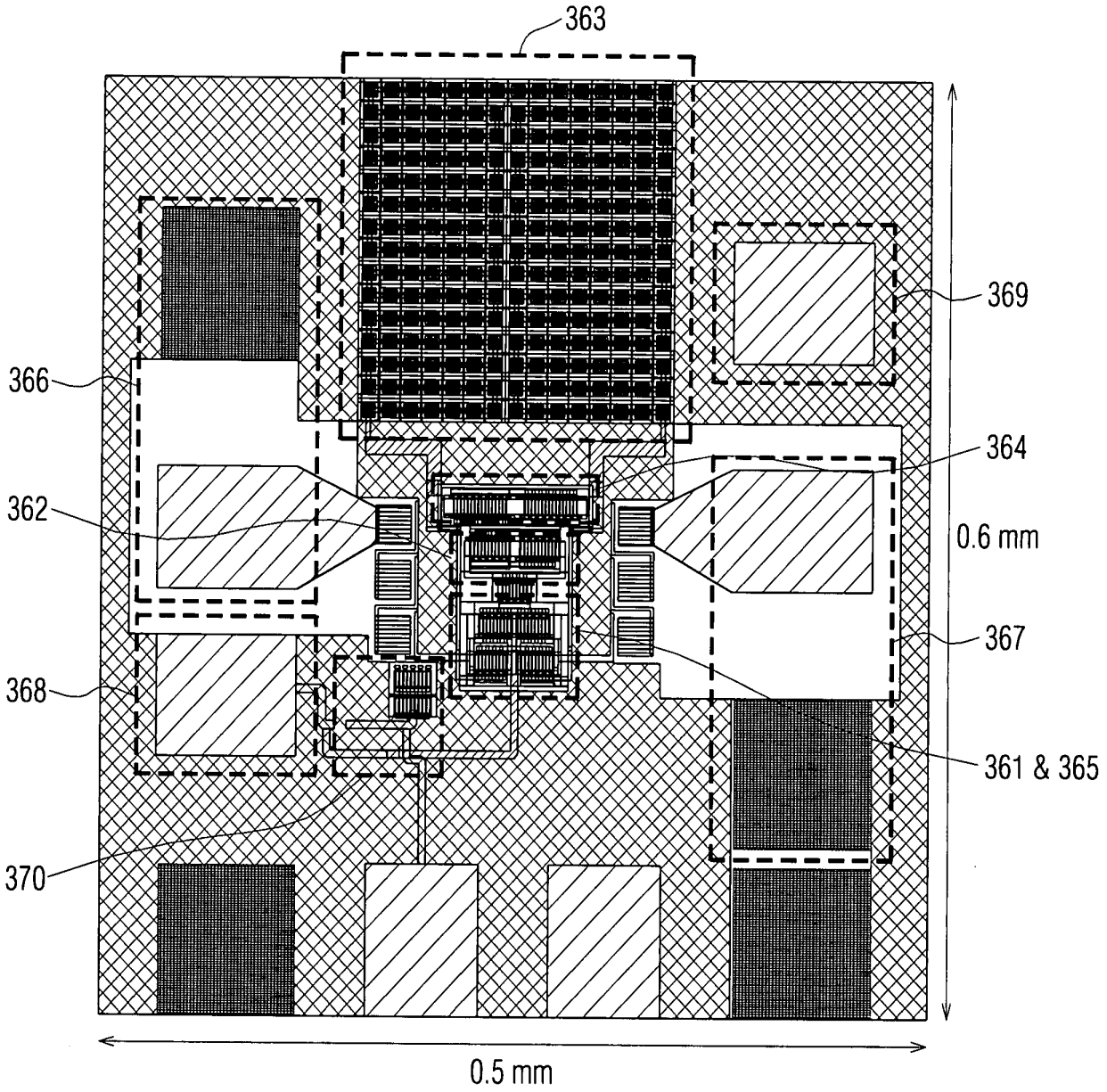


FIG. 15

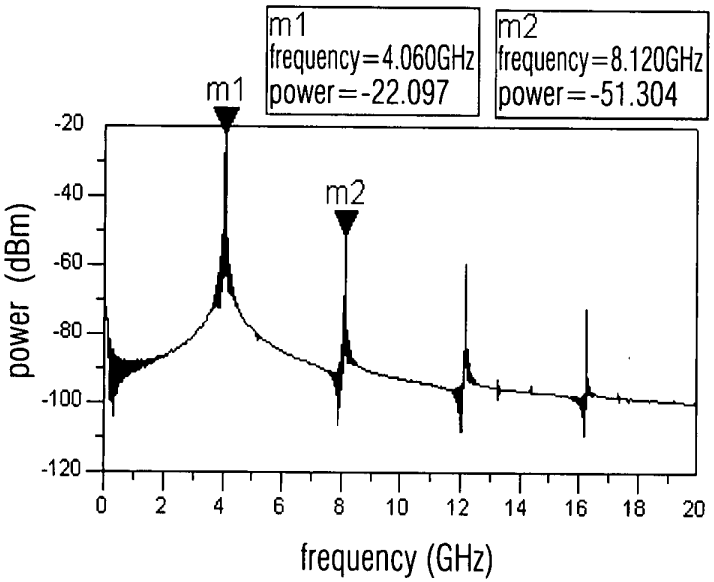


FIG. 16A

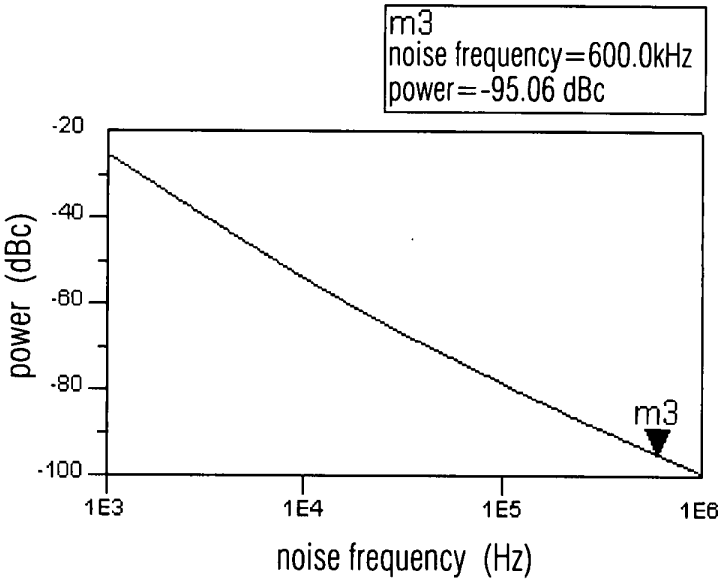


FIG. 16B